Age Characteristics in a Multidecadal Arctic Sea Ice Simulation

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Beginning in the late 1970s, the satellite era opened a viewing window for the large-scale variability of the polar regions. Substantive changes to the Arctic sea ice pack over the past decade are becoming apparent, most notably as reductions in area coverage in summer. Although more difficult to observe, other fundamental characteristics of the pack ice are also changing, such as ice thickness. Ice thickness is closely related to the age of the ice, because thickening through growth and ridging accumulates over time. Older ice, and by association thicker ice, possesses different characteristics than younger, thinner ice by virtue of the aging process, particularly desalination through brine channels and associated changes in albedo. Changes in the physical characteristics of the ice pack due to its transition from older to younger ice will have ramifications for the strength of feedbacks and ecosystem structure.

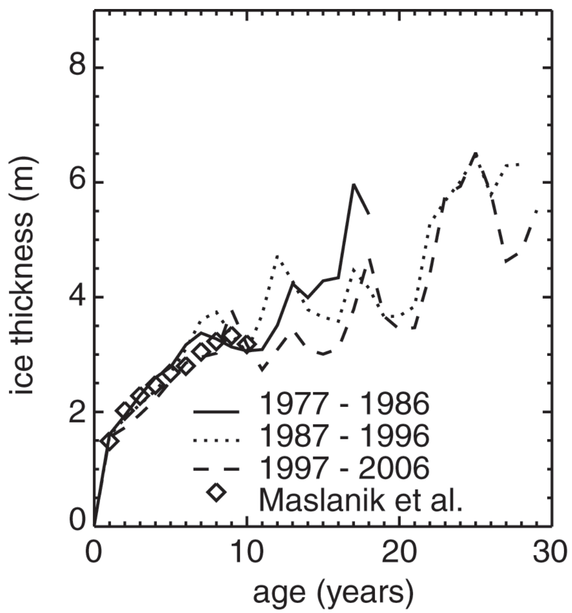

Fig. 1. Average March thickness of ice plotted against ice age, for three decades, and the Maslanik et al. [1] proxy ice thickness estimates for 2003– 2006. Model data are plotted only for age bins that are populated for all 10 years of each averaging period, Thus our results show that ice age is not a good proxy for sea ice thickness in a given year.

In light of research suggesting recent thinning of Arctic sea ice, and in the absence of basin-wide, detailed thickness observations, there has been much interest in obtaining ice age estimates from satellite data with which to infer and understand changes in the volume of Arctic sea ice. Recently, Maslanik et al. [1] used correlations of laser altimeter ice thickness data for 2003–2006 with estimates of sea ice age, inferred from a simple advection scheme using satellite-observed ice concentration and velocity, to develop an ice thickness proxy that could be used to create maps of ice volume in prior years.

Their results are shown in Fig. 1 against the output from our simulation using the Los Alamos sea ice model, CICE 4.0, a numerical sea ice model used for global climate studies. The model allows consistent simulation of ice age, dynamics, and thermodynamics, which satellite-based estimates lack. Agreement is remarkably good for ice up to 10 years old. However, neither spatial patterns nor interannual variability of ice age and ice thickness are as closely related as might be deduced from the Maslanik et al. proxy. Figure 2 illustrates modeled ice thickness and age in March of 1976, 1986, 1996, and 2006. Near the Canadian Archipelago, where ice is very thick and old, and near the Siberian coast, where ice tends to be thin and young, the age and thickness contours line up well. In the central Arctic, however, dynamic processes contribute to the complexity of the pack's physical characteristics through large-scale ice motion and smaller scale processes such as rafting and ridging.

Our model simulation reinforces the observationalists' story: older ice types have declined in the Arctic ice cover. However, although our model exhibits the expected relationship between ice age and thickness on multiyear and Northern Hemisphere-wide averages, we find that the correlation between ice age and thickness breaks down at the local scale (100s of kilometers and smaller) in [2].

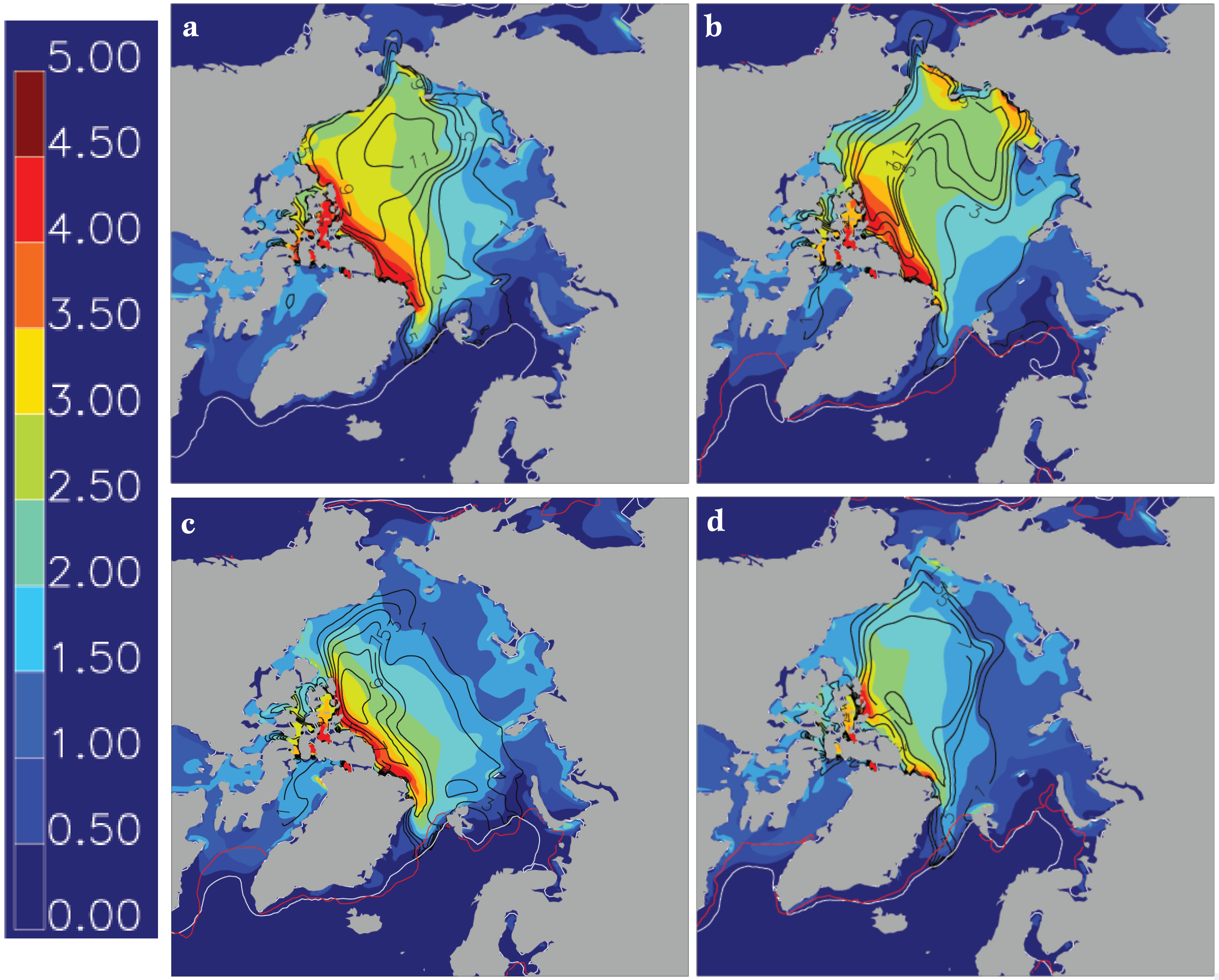

Fig. 2. March ice thickness, in m, for (a) 1976, (b) 1986, (c) 1996, and (d) 2006, overlain with ice age contours in black (2-year increments). The 15% simulated area concentration contour is white, and the satellite-observed 15% area contour is red.

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[1] J.A. Maslanik et al., *Geophys. Res. Lett.,* **34**, L24501, doi:10.1029/2007GL032043 (2007).
[2] E.C. Hunke, C.M. Bitz. "Age characteristics in a multidecadal Arctic sea ice simulation." *J. Geophys. Res.,* in review (2009).

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